

# Incidence of Injuries in High School Softball and Baseball Players

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**Context:** Participation in high school sports has grown 16.1% over the last decade, but few studies have compared the overall injury risks in girls' softball and boys' baseball.

**Objective:** To examine the incidence of injury in high school softball and baseball players.

**Design:** Cohort study.

**Setting:** Greenville, South Carolina, high schools.

**Patients or Other Participants:** Softball and baseball players ( $n=247$ ) from 11 high schools.

**Main Outcome Measure(s):** Injury rates, locations, types; initial or subsequent injury; practice or game setting; positions played; seasonal trends.

**Results:** The overall incidence injury rate was 4.5/1000 athlete-exposures (AEs), with more injuries overall in softball players (5.6/1000 AEs) than in baseball players (4.0/1000 AEs). Baseball players had a higher initial injury rate (75.9/1000 AEs) than softball players (66.4/1000 AEs): rate ratio (RR)=0.88, 95% confidence interval (CI)=0.4, 1.7. The initial injury rate was

higher than the subsequent injury rate for the overall sample ( $P<.0001$ ) and for softball ( $P<.0001$ ) and baseball ( $P<.001$ ) players. For both sports, the injury rate during games (4.6/1000 AEs) was similar to that during practices (4.1/1000 AEs), RR=1.22, 95% CI=0.7, 2.2. Softball players were more likely to be injured in a game than were baseball players (RR=1.92, 95% CI=0.8, 4.3). Most injuries (77%) were mild (3.5/1000 AEs). The upper extremity accounted for the highest proportion of injuries (63.3%). The incidence of injury for pitchers was 37.3% and for position players was 15.3%. The rate of injury was highest during the first month of the season (7.96/1000 AEs).

**Conclusions:** The incidence of injury was low for both softball and baseball. Most injuries were minor and affected the upper extremity. The injury rates were highest in the first month of the season, so prevention strategies should be focused on minimizing injuries and monitoring players early in the season.

**Key Words:** injury rates, injury epidemiology, athletic injuries

## Key Points

- Both softball and baseball players experienced a low incidence of injury.
- Most injuries were minor and affected the upper extremity.
- Injury rates were highest during the first month of the season, suggesting that athletes may benefit from a more gradual increase in activity and a structured off-season injury prevention program.

According to the National Federation of State High School Associations,<sup>1</sup> almost 369000 girls and more than 473000 boys participated in interscholastic softball and baseball during the 2008–2009 school year. These participation estimates represent increases of 8.4% and 3.9%, respectively, in the past decade.<sup>1</sup> Softball and baseball ranked as the third most popular high school sports for girls and boys, respectively.<sup>1</sup>

Information about the incidence, body location injured, and type of injury in high school softball and baseball players is limited. The overall incidence of injury, adjusted for athlete-exposure (AE), during an interscholastic season has ranged from 0.95 to 3.5 per 1000 AEs for softball players and 0.96 to 2.8 AEs for baseball players.<sup>2,3</sup> The body locations at greatest risk of injury vary by study. Rechel et al<sup>4</sup> reported that the lower extremity was the most frequently injured body region in softball and baseball. In contrast, Bonza et al<sup>5</sup> observed that the

greatest percentage of injuries was to the shoulder in both softball (10.4%) and baseball (17.7%) players. Powell and Barber-Foss<sup>6,7</sup> noted that the forearm, wrist, and hand was the most often injured body site in both sports. For high school softball and baseball athletes, the most common injury types have been muscle strains, ligament sprains, contusions, and general trauma,<sup>4,6,7</sup> with strains<sup>6,7</sup> and sprains having the highest incidence.<sup>8</sup>

The current literature suggests that factors such as subsequent injury,<sup>9–12</sup> reinjury,<sup>13</sup> and player position<sup>10,12</sup> may play important roles as risk factors for high school athletes. However, few authors have reported on these factors for interscholastic softball<sup>9,13</sup> or baseball.<sup>13</sup> Furthermore, descriptive studies on injury risk have not provided a comprehensive comparison of these factors for high school softball and baseball players.

The purpose of our study was to prospectively examine the incidence of injury in a cohort of high school softball and base-

ball players. Our objectives were to (1) determine initial and subsequent injury rates (injury to the same or a different body part that occurred after the player's initial injury), (2) compare the incidence of injury between softball and baseball and between practices and competitions, and (3) describe injuries by body location, injury type, time lost from injury (injury severity), seasonal injury trends by month, and position played.

## METHODS

### Participants and Setting

The study followed 10 softball and 8 baseball teams in 11 Greenville, South Carolina, high schools during the 2009 softball and baseball seasons. Of the 302 athletes who competed during the 2009 season, 247 (82%; 103 girls, 144 boys) agreed to participate. The Rocky Mountain University of Health Professions Institutional Review Board approved the study. Parental consent and participant assent were obtained before the study began, and the players completed a preseason questionnaire on general demographic information (sex, age), and current positions played.

### Injuries and AEs

From the first official day of practice until the last regular or postseason competition, 2 parallel recording procedures, the Simtrak Mobility system (version 8; Premier Software, Inc, Winfield, IL) and the Athletic Health Care System Daily Injury Report (DIR) form,<sup>11,14</sup> were used to track AEs, injury incidence, and participation absence or limitation due to injury. The Simtrak Mobility system is an electronic injury-tracking system that had already been used by the athletic trainers (ATs) involved in this study for 3 full years.

Before the 2009 spring interscholastic season, during 3 separate meetings, the ATs were trained in the use of the DIR form.<sup>11,14</sup> Premier Software, Inc, provided the original training on the use of Simtrak Mobility system to all ATs.

All athletes who reported pain or injury to their coach were referred to the AT at their school for evaluation and classification of each injury. All injuries, regardless of onset type (gradual or immediate), were recorded. A *baseball or softball injury* was defined as any injury that occurred during any baseball or softball team-sponsored activity (from the beginning of preseason through the last postseason game) to any muscle, joint, tendon, ligament, bone, or nerve of any body site reported by the player

to the coach or AT.<sup>11</sup> Injuries were classified as initial or subsequent. An *initial injury* was defined as the player's first injury during the season, and *subsequent injury* was any injury to the same or a different body part that occurred after the player's initial injury.<sup>9</sup> Time-lost classifications used to assess injury severity were mild (fewer than 8 days lost) and moderate/major (8 or more days lost).<sup>9</sup> The ATs entered the injury data and then met with research personnel each week to review the data on the DIR forms. These data were compared with those from the Simtrak Mobility system to assess data consistency each week.

The coaches were trained during a 1-day session and asked to report only attendance and participation in team activities to the ATs. Research personnel met with the coaches each week to ensure proper data recording and to answer any questions. An *AE* was defined as 1 athlete participating in 1 practice or competition.<sup>10,11</sup>

### Data Analysis

Incidence rates were calculated per 1000 AEs for initial and subsequent injuries, practices and games, and injury severity (time lost, categorized as mild [*fewer than 8 days lost*] or moderate/major [*8 or more days lost*]).<sup>9</sup> The total injury rate was considered the total number of injuries divided by the total number of AEs. For the initial injury rate, the numerator was restricted to the initial injury for each player and the denominator to AEs up to the initial injury.<sup>10,11</sup> For the subsequent injury rate, the numerator was restricted to injuries after the initial injury for each player and the denominator to AEs after the initial injury.<sup>10,11</sup> Because of our small sample size of high school athletes, we compared proportions of injuries by positions played and by sites and types of injuries. Monthly injury trends were examined for overall occurrence by sport and body location. Rate ratios (RRs) and 95% confidence intervals (CIs) were computed to compare injury rates between softball and baseball players for initial and subsequent injuries, injury setting (practice versus game), time lost (severity of injury), and body site injured by position. Relative risks and 95% CIs were calculated to compare initial upper extremity injury risks for pitchers and position players. The significance of all rate ratios was established with  $\chi^2$  tests. Data were analyzed using SPSS software (version 17.0; SPSS Inc, Chicago, IL).

## RESULTS

The injury incidence rate for the overall cohort was 4.5/1000 AEs (95% CI=3.4, 6.0) (Table 1). Although softball players (5.6/1000 AEs, 95% CI=3.5, 8.5) had a higher overall injury

**Table 1. Injury Rates and Injury Severity, High School Softball and Baseball Players, 2009 Season**

| Injury Category             | Total |                                |                   | Softball Players |                   |      | Baseball Players |                   |      | Rate Ratio                |
|-----------------------------|-------|--------------------------------|-------------------|------------------|-------------------|------|------------------|-------------------|------|---------------------------|
|                             | No.   | Athlete-Exposures <sup>a</sup> | Rate <sup>b</sup> | No.              | Athlete-Exposures | Rate | No.              | Athlete-Exposures | Rate | (95% Confidence Interval) |
| Onset                       |       |                                |                   |                  |                   |      |                  |                   |      |                           |
| Initial                     | 39    | 544                            | 71.7              | 16               | 241               | 66.4 | 23               | 303               | 75.9 | 0.88 (0.4, 1.7)           |
| Subsequent                  | 10    | 10264                          | 1.0               | 5                | 3519              | 1.4  | 5                | 6745              | 0.8  | 1.92 (0.4, 8.3)           |
| Total                       | 49    | 10808                          | 4.5               | 21               | 3760              | 5.6  | 28               | 7048              | 4.0  | 1.40 (0.8, 2.6)           |
| Severity                    |       |                                |                   |                  |                   |      |                  |                   |      |                           |
| <8 d time loss              | 38    | 10808                          | 3.5               | 17               | 3760              | 4.5  | 21               | 7048              | 3.0  | 1.52 (0.8, 3.0)           |
| ≥8 d time loss <sup>c</sup> | 11    | 10808                          | 1.0               | 4                | 3760              | 1.1  | 7                | 7048              | 1.0  | 1.07 (0.3, 4.2)           |

<sup>a</sup> Athlete-exposure: each time a player participated in a practice or a game without limitation, being exposed to injury.

<sup>b</sup> Rate: Injury rate per 1000 athlete-exposures.

<sup>c</sup> Includes 1 major injury with more than 21 days' time loss.

rate than did baseball players (4.0/1000 AEs, 95% CI=2.6, 5.7), the difference was not significant (RR=1.4, 95% CI=0.8, 2.6,  $P=.28$ ). Baseball players had a slightly higher initial injury rate than did softball players (RR=0.88, 95% CI=0.4, 1.7,  $P=.69$ ) (Table 1). The rates for initial injuries were higher than for subsequent injuries in the overall sample (RR=73.6, 95% CI=36.1, 165.3,  $P<.0001$ ), softball (RR=46.7, 95% CI=16.4, 163.1,  $P<.0001$ ), and baseball (RR=102.4, 95% CI=38.1, 344.8,  $P<.001$ ). Although the rate of subsequent injury was almost twice as high for softball players as for baseball players, the difference was not significant (RR=1.92, 95% CI=0.4, 8.3). Most injuries (77%,  $n=38$ ) were mild (3.5/1000 AEs, 95% CI=2.5, 4.8), with similar patterns of injury severity for softball and baseball players (Table 1).

Overall, the injury rate during games (4.9/1000 AEs, 95% CI=3.3, 7.1) was not significantly different from the injury rate during practices (4.1/1000 AEs, 95% CI=2.5, 6.2) (RR=1.22, 95% CI=0.7, 2.2,  $P=.54$ ), with similar patterns observed for softball and baseball (Table 2). Softball players were more likely to be injured in a game (7.2/1000 AEs, 95% CI=3.9, 12.0) than were baseball players (3.8/1000 AEs, 95% CI=2.3, 7.1), but the difference was not significant (RR=1.92, 95% CI=0.8, 4.3,  $P=.09$ ).

On the whole, more than one-third of pitchers (37.2%,  $n=19$ ) sustained an injury during the 2009 season. For baseball, a slightly higher proportion of injuries was incurred by position players (53.6%,  $n=15$ ) than by pitchers (46.4%,  $n=13$ ). Although 50% (6/12) of the softball pitchers sustained injuries, these 6 injuries represented only 28.5% of all softball injuries.

By body site, the proportion of injuries was highest for the shoulder (34.7%) and elbow (28.6%), with similar patterns for softball and baseball players (Table 3). Similar proportions of shoulder injuries were reported for softball (38.1%,  $n=8$ ) and baseball (32.1%,  $n=9$ ) players. Of all injuries, 31 (63.3%) occurred at the upper extremity (shoulder=17, elbow=14). Overall, pitchers experienced 47.1% ( $n=8$ ) of all shoulder injuries (Table 3). Baseball players sustained 12 of the 14 elbow injuries (85.7%) reported. No softball pitcher reported elbow pain during the season. The risk of an upper extremity (shoulder or elbow) injury to a pitcher was 2.6 times as great (RR=2.6, 95% CI=1.3, 5.3,  $P=.005$ ) as the risk to a position player. For baseball, pitchers were 3.6 times as likely to incur an upper extremity injury as position players (RR=3.6, 95% CI=1.4, 8.9,  $P=.003$ ). For softball, position players and pitchers were at similar risk of an upper extremity injury in our sample (RR=0.83, 95% CI=0.11, 6.1,  $P=.86$ ). Overall, muscle strains (59.2%,  $n=29$ ) were the most common injury type sustained, with similar patterns for both sports (Table 3).

The overall rate of injury was highest for the first month of the season (7.96/1000 AEs, 95% CI=5.4, 11.3), followed by the third (4.72/1000 AEs, 95% CI=1.3, 12.0) and second (3.0/1000 AEs, 95% CI=1.6, 5.0) months, respectively. The occurrence of shoulder injuries was highest (3.3/1000 AEs, 95% CI=1.8, 5.7; Figure 1) in the first month of the season, whereas the rate of elbow injury was highest (2.4/1000 AEs, 95% CI=1.6, 8.5; Figure 2) in the third month of the season. We found different shoulder and elbow injury patterns for softball and baseball players. For shoulder injuries, the rate was highest for both sports at the beginning of the season and then markedly lower in the second and third months (Figure 1). Conversely, a J-shaped pattern for elbow injury was observed for baseball players: the highest rate of elbow injury occurred at the end of

**Table 2. Injury Incidence and Risk Estimates for Games and Practices, High School Softball and Baseball Players, 2009 Season**

| Injury Onset and Setting | Total |                                |                   | Softball Players                                      |                   |      | Baseball Players                                      |                   |   |
|--------------------------|-------|--------------------------------|-------------------|---|-------------------|------|---|-------------------|---|
|                          | No.   | Athlete-Exposures <sup>a</sup> | Rate <sup>b</sup> | Rate Ratio: Games/Practices (95% Confidence Interval) |                   | Rate | Rate Ratio: Games/Practices (95% Confidence Interval) |                   | Rate Ratio: Softball/Baseball (95% Confidence Interval) |
|                          |       |                                |                   | No.   | Athlete-Exposures |      | No.   | Athlete-Exposures |   |
| Initial injury           |       |                                |                   |   |                   |      |   |                   |   |
| Games                    | 21    | 266                            | 79.0              | 9   | 125               | 72.0 | 12  | 141               | 0.85 (0.5, 3.7)   |
| Practices                | 18    | 278                            | 64.8              | 7   | 124               | 56.5 | 11  | 154               | 0.79 (0.3, 2.2)   |
| Subsequent injury        |       |                                |                   |   |                   |      |   |                   |   |
| Games                    | 28    | 5679                           | 4.9               | 14  | 1945              | 7.2  | 14  | 3734              | 1.92 (0.8, 4.3)   |
| Practices                | 21    | 5129                           | 4.1               | 7   | 1815              | 3.9  | 14  | 3314              | 0.91 (0.3, 2.4)   |

Abbreviation: CI, confidence interval.

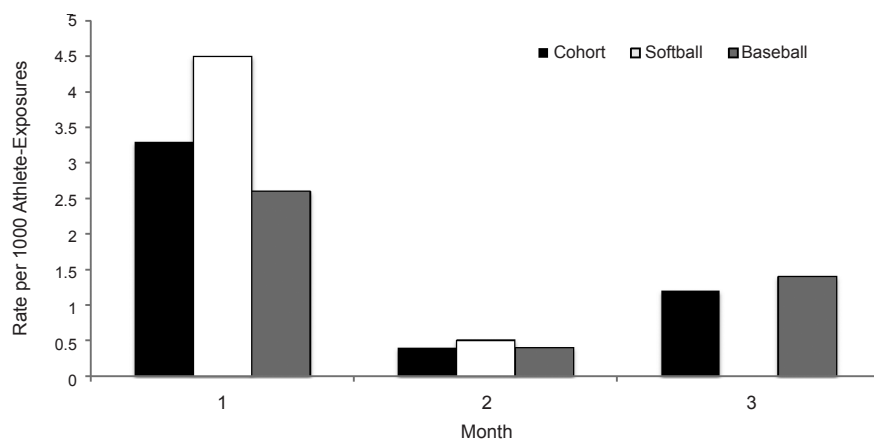
<sup>a</sup>Athlete-exposure: each time a player participated in a practice or a game without limitation, being exposed to injury.

<sup>b</sup>Rate: Injury rate per 1000 athlete-exposures.

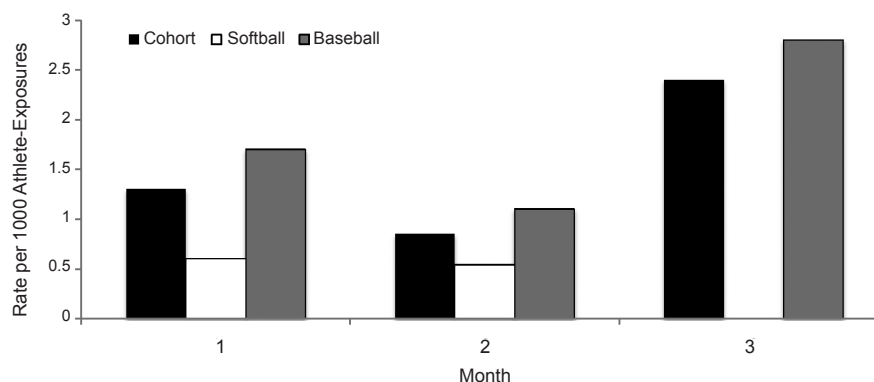
**Table 3. Number (%) of Injuries by Body Site and Diagnosis by Player Position, High School Softball and Baseball Players, 2009 Season**

| Injury Site and Diagnosis      | Total              |                        | Softball Players   |                       | Baseball Players   |                        |
|--------------------------------|--------------------|------------------------|--------------------|-----------------------|--------------------|------------------------|
|                                | Pitchers<br>(n=51) | Nonpitchers<br>(n=196) | Pitchers<br>(n=12) | Nonpitchers<br>(n=91) | Pitchers<br>(n=39) | Nonpitchers<br>(n=105) |
| <b>Site</b>                    |                    |                        |                    |                       |                    |                        |
| Head, neck, torso              | 3 (5.9)            | 4 (2.0)                | 2 (16.7)           | 3 (3.2)               | 1 (2.6)            | 1 (1.0)                |
| Shoulder                       | 8 (15.6)           | 9 (4.6)                | 2 (16.7)           | 6 (6.6)               | 6 (15.4)           | 3 (2.9)                |
| Elbow                          | 5 (9.8)            | 9 (4.6)                | 0 (0)              | 2 (2.2)               | 5 (12.8)           | 7 (6.7)                |
| Forearm, wrist, hand           | 1 (1.9)            | 0 (0)                  | 1 (8.3)            | 0 (0)                 | 0 (0)              | 0 (0)                  |
| Leg                            | 2 (3.9)            | 8 (4.1)                | 1 (8.3)            | 4 (4.4)               | 1 (2.6)            | 4 (3.8)                |
| <b>Diagnosis</b>               |                    |                        |                    |                       |                    |                        |
| Strains <sup>a</sup>           | 13 (25.5)          | 16 (8.2)               | 4 (33.3)           | 7 (7.7)               | 9 (23.1)           | 9 (8.6)                |
| Sprains                        | 2 (3.9)            | 9 (4.6)                | 1 (8.3)            | 4 (4.4)               | 1 (2.5)            | 5 (4.8)                |
| Other musculoskeletal injuries | 4 (7.8)            | 5 (2.6)                | 1 (8.3)            | 4 (4.4)               | 3 (7.7)            | 1 (1.0)                |
| <b>Total</b>                   | <b>19 (37.2)</b>   | <b>30 (15.3)</b>       | <b>6 (50.0)</b>    | <b>15 (16.5)</b>      | <b>13 (33.3)</b>   | <b>15 (14.3)</b>       |

<sup>a</sup>Strains include impingement injuries.



**Figure 1. Monthly shoulder injury rate, high school softball and baseball players, 2009 season.**



**Figure 2. Monthly elbow injury rate, high school softball and baseball players, 2009 season.**

the season, whereas the rate of elbow injury declined over the course of the season for softball players (Figure 2).

## DISCUSSION

### Main Findings

Overall injury rates were low in interscholastic softball and baseball players. Initial injury rates were significantly higher than subsequent injury rates, and initial injuries affected primarily the upper extremity. Most injuries were minor and

classified as strains. Pitchers were at greater risk than position players of sustaining an upper extremity injury, especially in baseball. The greatest proportion of injuries was sustained in the first month of the season, especially to the shoulder, and different seasonal patterns of elbow injury existed for softball and baseball players.

### Overall, Initial, and Subsequent Injuries

During the 12-week season, the overall injury rates were low for interscholastic softball (5.6/1000 AEs) and baseball



(4.0/1000 AEs) players. These rates are higher than those indicated for high school softball and baseball players in recent reports.<sup>2,3</sup> When we compared the injury rates between these sports, our results were in agreement with those of several authors<sup>3,6,13,15</sup> but disagreed with those observed by Rechel et al<sup>4</sup> in a larger, more geographically diverse study of softball and baseball players. They<sup>4</sup> reported that baseball players had a slightly higher injury rate than did softball players. The equivocal agreement between studies may be attributed to differences in injury definitions, participant populations (including athletes at different levels of competition), sample size, and sampling methods.

The initial injury rate in our study was higher than that in previous reports.<sup>2-4,6-8,15</sup> Of our 39 initial injuries, 11 (28%) occurred in the first week of the regular season, by which time only 8% of the total season participation exposures had occurred. Although the mean time for any initial injury to occur was  $15.0 \pm 12.8$  days, the mean time for an initial upper extremity injury occurrence was  $13.9 \pm 12.1$  days. These results may be attributed to the short preseason, immediate introduction of tournament competition, and lack of a structured off-season program for all athletes, but it is important to interpret these findings with caution because of our small sample size.

The distinction between the initial injury and subsequent injuries has been reported in only a few previous high school studies reporting injuries.<sup>9,13</sup> We described our findings in this manner because the occurrence of an injury may be a risk factor for subsequent injury at the same site.<sup>16,17</sup> We found that the initial injury rate was higher than the subsequent injury rate for both softball and baseball players. Approximately 80% of the injuries we reported were new injuries, a finding that is consistent with a report published by the Centers for Disease Control and Prevention<sup>2</sup> in 2006. Although we are not aware of any authors who have examined the effect of subsequent injury in these 2 sports with respect to AEs, our finding is in direct contrast to findings in high school cross-country runners.<sup>9,11</sup> For comparative purposes, we calculated the initial and subsequent injury risks per 100 athletes. The initial and subsequent risks for softball were 15.5 and 31.3 per 100 athletes, respectively. These estimates are similar to those previously reported by Rauh et al<sup>9</sup> for girls' high school softball players, and they illustrate the importance of using a denominator that controls for actual risk of participation (ie, AE). That is, when estimated by actual participation, the subsequent rate was significantly lower than the initial rate, but when determined per 100 athletes, the subsequent risk was twice as high as the initial injury risk. When we used AEs as an accurate denominator to measure injury risk,<sup>18,19</sup> the risk of a subsequent injury was low for girls' high school softball players, with a rate of 1.4/1000 AEs. Most softball-related injuries were incurred early in the season, with minimal time loss. Because players were treated promptly at the time of their injuries and then monitored closely, the risk of a subsequent injury during the rest of the season may have been minimized. Similar initial (16.0) and subsequent (21.7) risks per 100 athletes were also found for high school baseball players. No reports are currently available for comparison, but the difference we observed when evaluating risk by AE or 100 athletes complements the findings found for girls' softball players. Nevertheless, it should be noted that the subsequent risk for softball players was almost twice that of baseball players. This risk was not statistically significant and was probably due to the small sample sizes, yet this finding suggests that softball

players may incur additional injuries and should be monitored closely after their initial injury for the remainder of the season. Swenson et al<sup>13</sup> also reported higher rates of new injuries than recurrent injuries in softball and baseball players. However, their definition of recurrent injury included only reinjury to the same body part and did not include subsequent new injuries (injury to a different body part that occurred after the player's initial injury). Therefore, comparing our subsequent injury rates with theirs is difficult.

### **Injuries by Severity**

Authors<sup>6,13</sup> of recent studies of high school softball and baseball players demonstrated that most injuries are minor, causing the athlete to miss only 7 or fewer days of participation. Our findings are consistent with these studies in that most injuries (77%) sustained by softball and baseball players were classified as minor. The consistency of these findings supports the notion that injuries in these sports cause minimal disability, which may reflect early recognition and management of the injuries.

### **Injuries by Exposure Type**

As reported by Rechel et al<sup>4</sup> and the Centers for Disease Control and Prevention<sup>2</sup> and based on data from the same 100-school sample, high school softball and baseball players had higher rates of injury during games than during practices. Although we found a similar trend for our softball players, we observed almost no difference in rates by setting for baseball players. Knowles et al<sup>15</sup> noted that high school softball and baseball players had higher rates of injury during practices than during games. The differences between our findings and theirs may be related to their larger sample size, greater geographic diversity, and higher competition level. The high early-season injury rates for the baseball players in our study may have been affected by the heavy concentration of practices at that time. As Bonza et al<sup>5</sup> did, we found that shoulder injuries occurred more often in games than in practices in both softball and baseball players.

### **Injuries by Position**

Few researchers have characterized injuries to players by position.<sup>8,20</sup> According to Collins and Comstock,<sup>8</sup> only 20% of the injuries reported over a 2-year study period occurred in baseball pitchers, which supports our findings. In our study, the overall injury occurrence was also higher for position players than pitchers. However, we recommend some caution when interpreting this finding. Injury frequency by position was difficult to assess when pitchers also played field positions. Thus, for these athletes some nonacute injuries were classified by their playing position on the day the injury was reported, not by the playing position in which the injury might have been incurred or developed.

### **Injuries by Body Location**

Overall, the shoulder was the most frequently injured body location, followed by the elbow, but the risk of injury to these body locations differed by sport. The shoulder has been identified as one of the most commonly injured body locations in high school softball and baseball athletes.<sup>5,7,20</sup> In our study, elbow injuries were sustained more frequently in baseball than

in softball, but because other authors<sup>4,8,20</sup> did not report elbow injuries as a specific body location, comparing these results is challenging. Unlike Powell and Barber-Foss,<sup>6,7</sup> we did not observe a forearm, wrist, or hand injury among the softball or baseball players. Moreover, few contact injuries occurred in our study, which may explain the lower incidence of distal upper extremity injuries.

To our knowledge, few investigators have reported the effect of player position on injury characteristics in baseball players<sup>8</sup> or softball baseball players by position.<sup>20</sup> Our results should be interpreted with caution because our sample size and injury numbers were small. When all position players were considered as a group,<sup>8,20</sup> the overall frequency of shoulder injuries was slightly higher in position players than in pitchers. Although we also found that the occurrence for shoulder injuries was highest in softball position players, the baseball pitchers in our study had a higher percentage of injuries than the baseball position players. Some methodologic differences prohibit a direct comparison of our findings with other studies. For example, in some investigations<sup>8,20</sup> the injuries were attributed to specific tasks (eg, hitting, running, throwing) and by position when the athlete was injured playing the position; we attributed the injury to player by position regardless of task. Comparison by sport revealed that shoulder injuries were concentrated in softball position players and baseball pitchers. Pitchers sustained 5 of the 9 elbow injuries in baseball but 0 of 2 injuries in softball. It is possible that the windmill pitching motion is not as stressful to the elbow, but similar physical stresses have been reported in biomechanical studies of baseball and softball pitching.<sup>21,22</sup> These results may be clinically significant, but additional studies with larger sample sizes are needed to confirm our findings. Further studies with a greater diversity of geography and competition levels will help us determine whether this phenomenon is associated with geography or the high school level.

### Injuries by Injury Type

Rechel et al<sup>4</sup> reported that strains and sprains were the most common injury types across sports. In a recent study<sup>8</sup> of high school baseball players, sprains were the most common injury type, followed by strains. In another investigation,<sup>20</sup> many shoulder injuries in high school softball and baseball players were muscle tendon strains. We found that the most common injuries were strains, followed by sprains, a result that is consistent with reports from Rechel et al<sup>4</sup> and Krajnik et al.<sup>20</sup> However, the populations for both studies<sup>4,20</sup> were from the same database of 100 schools, which may influence the generalization of our findings.

### Monthly Injury Trends Across the Playing Season

To our knowledge, we are the first to prospectively examine seasonal trends of injury by month for a cohort of high school softball and baseball players. After adjusting for actual participant exposure, we noted that the highest risk of injury for players in both sports was during the first month of the season. Pitchers were more likely to sustain an upper extremity injury during the first month, and all upper extremity pitching injuries occurred within the first 8 weeks of the 12-week season. In our limited sample (247 players with 27 initial upper extremity injuries: 16 to the shoulder, 11 to the elbow), softball and baseball players were more likely to incur a shoulder injury during the

first month of the season than during the next 2 months; softball players in particular were more likely to sustain a shoulder injury during the first month of the season than during the remainder of the season. Future authors should examine seasonal trends for shoulder and elbow injuries in a larger sample over a longer study period to determine their importance. These findings may be attributable to the short preseason and the lack of a structured off-season program for all athletes. Although further research is needed in this area, our findings suggest that athletes in these sports might benefit from a more gradual increase in exposure to the repetitive activities of these sports and a structured off-season injury prevention program.

### Implications of Sex

Despite significant differences between softball and baseball in ball weight, pitching surface, and field dimensions, softball and baseball players had similar injury rates and patterns. Our results confirmed the hypotheses of other authors<sup>15,23,24</sup> who suggested the need for injury prevention strategies, such as pitch count regulations in softball, but larger studies are needed.

The upper extremity was the body region injured most often in softball and baseball players. Softball players sustained the most injuries to their shoulders, whereas baseball players incurred the most injuries to their elbows, followed by their shoulders. An important observation in our study was the frequency and pattern of injury at the elbow. Softball pitchers did not sustain any elbow injuries, and baseball pitchers sustained only a few injuries. Previous authors<sup>23</sup> have suggested that the use of the leg-slap technique after ball release may decrease stress to the elbows of softball pitchers. It is possible that the minimal shoulder rotation with elbow flexion before ball release may decrease valgus stress at the elbow during the windmill pitching motion. Baseball players sustained elbow injuries early and late in the season; softball position players sustained all their elbow injuries in the first 8 weeks.

### Study Strengths

The study's prospective design limited the likelihood of recall bias. We conducted our investigation over a small geographic area, which allowed us to control factors related to exposure (climate and competition level) and documentation of injury circumstances. Certified athletic trainers were present in each school to classify injury type and location and limit documentation errors. We contacted coaches and ATs each week, and data were collected with parallel systems to increase the accuracy of the results. The injury data were homogeneous with respect to the number of injuries recorded in the Simtrak Mobility system for the previous 2 years.

### Study Limitations

Several limitations of our study should be noted. First, the low incidence of injury in these sports and small sample size probably limited our ability to detect statistical differences for many of our rate comparisons. The characteristics and practice patterns of our high school softball and baseball teams may differ from those in other geographic regions, limiting the generalizability of the findings. Although calculating AEs by daily participation rather than by minutes of exposure may be a less precise measure of risk, it is probably a more practical method

for collecting reliable and accurate data. Finally, we were unable to examine injuries by task and therefore cannot assign a specific mechanism to each injury.

## CONCLUSIONS

Participation in high school baseball and softball continues to rise. Even though these sports are considered safe, modification of some training and competition characteristics, especially early and late in the season, may further reduce injury rates overall and especially to the upper extremity. Softball and baseball are similar sports in many ways, but differences exist. Additional examinations characterizing the epidemiologic features of injuries relating to position played, exposure to activity (eg, pitch counts), and task performed during injury are warranted to identify specific protective equipment and exposure limits to lower injury risks in high school softball and baseball players.

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